Adv. Biology: Human Evolution Study Guide

- Primates: what they are and some examples
  - Humans, apes, monkeys, and lemurs belong to a group of mammals known as primates. Though primates are highly diverse, they share some general features. Some primates have a high level of manual dexterity, which is the ability to manipulate or grasp objects with their hands. They usually also have keen eyesight and long, highly movable arms. Compared to other animals, they have large brains. The primates with the largest brains, which includes humans, have the capacity to reason.
- Arboreal - the majority of primates are arboreal, meaning that they have live in trees. (tree-dwelling). Arboreal primates live in the world's tropical and subtropical forests. Primates that live on the ground are considered terrestrial primates.
- Characteristics of primates

Manual dexterity Primates are distinguished by their flexible hands and feet. All primates typically have five digits on each hand and foot; as you know, humans have fingers and toes. Most have flat nails and sensitive areas on the ends of their digits. The first digits on most primates' hands are opposable, and the first digit on many primates' feet are opposable. An **opposable first digit,** either a thumb or a great toe, is set apart from the other digits. This digit can be brought across the palm or foot so that it touches or nearly touches the other digits. This action allows the primate to grasp an object in a powerful grip. Some primates also have lengthened first digits that provide added dexterity. **Figure 16.1** shows a monkey using its opposable thumbs to grasp its food.

Senses Though there are exceptions, primates rely more on vision and less on their sense of smell than other mammals do. Their eyes, protected by a bony eye socket, are on the front of their face. This creates overlapping fields of vision, often called **binocular vision.** Forward-looking eyes allow for a greater field of depth perception, and enable primates to judge relative distance and movement of an object.

Most primates are **diurnal** (di YUR nul), which means they are active during the day. Because these primates are active in daylight, most also have color vision. Primates that are **nocturnal** (nahk TUR nul) are active at night. They only see in black and white. An increased sense of vision is generally accompanied by a decreased sense of smell. Their snouts are smaller and their faces tend to be flattened, which increases the degree of binocular vision. Their teeth are reduced in size and usually are unspecialized, meaning that they are suitable for many different types of diets.

Locomotion Another characteristic of primates is their flexible bodies. Primates have limber shoulders and hips, and primarily rely on hind limbs for locomotion. Most primates live in trees and have developed an extraordinary ability to move easily from branch to branch. When on the ground, all primates except humans walk on all four limbs. Many primates can walk upright for short distances and many have a more upright posture compared to four-legged animals.

Complex brain and behaviors Primates tend to have large brains in relation to their body size. Their brains have fewer areas devoted to smell and more areas devoted to vision. They also tend to have larger areas devoted to memory and coordinating arm and leg movement. Along with larger brains, many primates have problem-solving abilities and well-developed social behaviors, such as grooming and communicating. Most diurnal primates spend a great deal of time socializing by spending time grooming each other. In addition, many primates have complex ways of communicating to each other, which include a wide range of facial expressions.

Reproductive rate Most primates have fewer offspring than other animals. Usually, primates give birth to one offspring at a time. Compared to other mammals, pregnancy is long, and newborns are dependent on their mothers for an extended period of time. For many primates, this time period allows for the increased learning of complex social interactions. A low reproductive rate, the loss of tropical habitats, and human predation has threatened some primate populations. Many are endangered. **Figure 16.2** illustrates the tropical areas of the world, such as Africa and Southeast Asia, where primates live.

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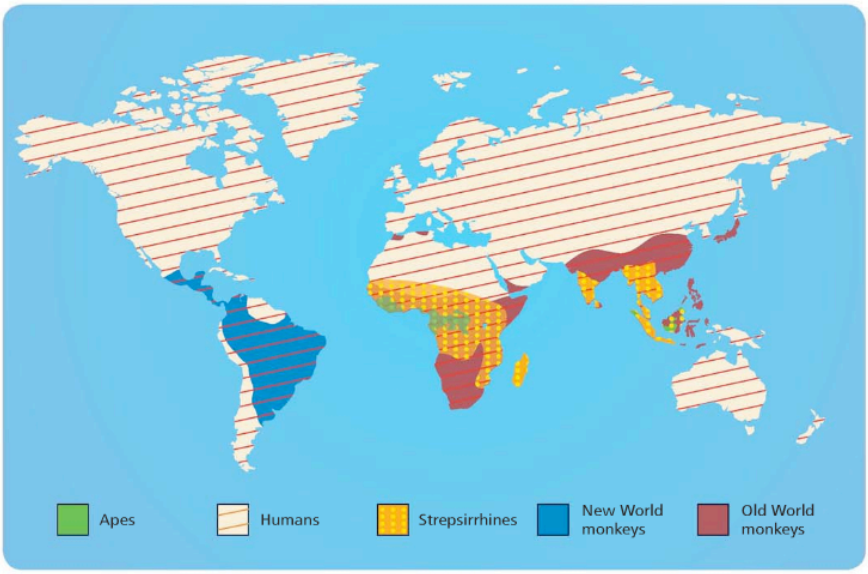
Figure 16.2 Non-human primates live in a broad area spanning most of the world's tropical regions. Use this map as you read about the different primates.



See above for descriptions

- Dexterity: five digits; opposable thumbs -

- Binocular vision - a characteristic of primates, which results in greater depth perception, and creates overlapping fields of vision
- Senses: which do they rely on the most? - They rely mostly on vision
  - They have binocular vision
  - Color vision
  - Decreased sense of smell (in relation to other animals.)
  - Teeth are reduced in size and usually unspecialized, unlike dogs for example who have specialized teeth.
- Flexible bodies
- Complex brain and behaviors

- Strepsirrhines and Haplorhines:

Primate Groups

Primates are a large, diverse group of more than 200 living species. Examine **Figure 16.3** as you read about this diverse group. Most primates are **arboreal** (ar BOHR ee uhl), or tree-dwelling. Arboreal primates live in the world's tropical and subtropical forests. Primates that live on the ground are considered terrestrial primates.

Primates are classified into two subgroups based on characteristics of their nose, eyes, and teeth. The most basic subgroup is the strepsirrhines (STREP sihr ines), (also called "wet-nosed primates"), such as the lemur. The second subgroup consists of the haplorhines (HAP lohr ines), also called "dry-nosed" primates. The haplorhines include the **anthropoids** (AN thruh poydz), a group of large-brained, diurnal monkeys and hominoids.

Strepsirrhines

Strepsirrhines can be identified by their large eyes and ears. However, they are the only primates that rely predominantly on smell for hunting and social interaction. Some members of this primate group can be found in tropical Africa and Asia. Most are found in Madagascar and nearby islands. Madagascar drifted away from the African mainland as these animals evolved leaving them reproductively isolated. This isolation resulted in their diversification. **Table 16.1** lists characteristics of some strepsirrhine groups.

VOCABULARY

WORD ORIGIN

Lemur
comes from Latin, meaning *spirit of the night.*

Table 16.1 **Characteristics of Strepsirrhines**

Concepts in MOtion
Interactive Table To explore more about strepsirrhines, visit biologygmh.com.

Group	Lemurs	Aye-Ayes	Lorises	Galagos
Example				
Active Period	Large—diurnal Small—nocturnal	Nocturnal	Nocturnal	Mostly nocturnal
Range	Madagascar	Madagascar	Africa and Southeast Asia	Africa
Characteristics	• Vertical leaper • Uses long bushy tail for balance • Herbivores and omnivores	• Taps bark, listens, fishes out grubs with long third finger	• Small and slow climber, solitary • Lack tails • Some have toxic secretions	• Small and fast leaper • No opposable digit • Long tail

Most small lemurs are nocturnal and solitary. Only a few large species, such as the sifaka shown in **Figure 16.4,** are diurnal and social. The indri is unique because it does not have a tail, unlike most lemurs that use their bushy tails for balance as they jump from branch to branch. Lorises are similar to lemurs but are found primarily in India and Southeast Asia. Galagos (ga LAY gohs), also called bushbabies, are found only in Africa.

Haplorhines

The second group of primates is a much larger group. The haplorhines include tarsiers, monkeys, and apes. The apes, in turn, include gibbons, orangutans, gorillas, chimpanzees, and humans.

The tarsier is found only on Borneo and the Philippines. It is a small, nocturnal creature with large eyes. It has the ability to rotate its head 180 degrees like an owl. It lives in trees, where it climbs and leaps among the branches. The tarsier shares characteristics with both lemurs and monkeys. Scientists once classified it with the lemurs, but new evidence suggests that it is more closely related to anthropoids, which makes it part of the haplorhine group.

Anthropoids are generally larger than strepsirrhines, and they have large brains relative to their body size. They are more likely to be diurnal, with eyes adapted to daylight and sometimes to color. Anthropoids also have more complex social interactions. They tend to live longer than lemurs and other strepsirrhines. The anthropoids are split into the New World monkeys and the Old World monkeys. "New World" refers to the Americas; "Old World" refers to Africa, Asia, and Europe. New World monkeys are the only monkeys that live in the Americas.

- Anthropoids: See above
  - what are they? – a group of large-brained diurnal monkeys and hominoids.
  - Characteristics of them – generally large than stepsirrhines, large brains in relation to body size.

- Old world and new world monkeys and their differences

New World monkeys The New World monkeys are a group of about 60 species of arboreal monkeys that inhabit the tropical forests of Mexico, Central America, and South America. New World monkeys include the marmosets and tamarins. These are among the smallest and most unique primates. Neither species has fingernails or opposable digits.

The New World monkeys also include the squirrel monkeys, spider monkeys, and capuchin monkeys. Some of these monkeys have opposable digits and most are diurnal and live together in social bands. Most are also distinguished by their prehensile (pree HEN sul) tails. A **prehensile tail** functions like a fifth limb. It can grasp tree branches or other objects and support a monkey's weight, like that shown in **Figure 16.5.**

Old World monkeys Old World monkeys live in a wide variety of habitats throughout Asia and Africa, from snow-covered mountains in Japan to arid grasslands in Africa. Some Old World monkeys live in Gibraltar, which is located at the southern tip of Spain. There are about 80 species in this group, including macaques and baboons in one subgroup, and colobus and proboscis monkeys in another. Old World monkeys are similar to New World monkeys in many ways. They are diurnal and live in social groups. However, their noses tend to be narrower and their bodies are usually larger. They also spend more time on the ground. None have prehensile tails, and some have no tails. Most Old World monkeys have opposable digits.

- Prehensile tails:
    - What are they? – Functions like a fifth limb that can grasp tree branches or other objects and support a monkey's weight.
    - What organisms have them? – New World Monkeys
    - Why are they beneficial? – See above
- Hominoids: Text below answers questions
    - what are they?
    - How are they classified?
    - What are their characteristics?

New Vocabulary

hominoid
bipedal
australopithecine

Hominoids

Hominoids (HAH mih noydz) include all nonmonkey anthropoids—the living and extinct gibbons, orangutans, chimpanzees, gorillas, and humans. The fossil transition from early anthropoid to ape is not clear; very few fossils from the late Oligocene exist. The earliest hominoid fossils appear in the fossil record only about 25 mya at the beginning of the Miocene. These hominoids retained some ancestral primate features. For example, most had bodies adapted for brachiation. There is evidence that they had relatively large brains and had shoulders and hips that moved freely, and some might even have had the ability to stand on two legs.

Connection to Chemistry Scientists use fossils to help them determine when ancestral hominoids diverged into the hominoids that exist today. But because the fossil record for hominoids is so sparse, scientists also turn to biochemical data to help them in this task. By comparing the DNA of living hominoid species, researchers conclude that gibbons likely diverged first from an ancestral anthropoid, followed by orangutans, gorillas, chimpanzees and bonobos, and finally, humans. **Figure 16.11** shows the potential divergence of these species. Chimpanzees and bonobos are the closest living relatives to humans. All three share at least 96 percent of their DNA sequences.

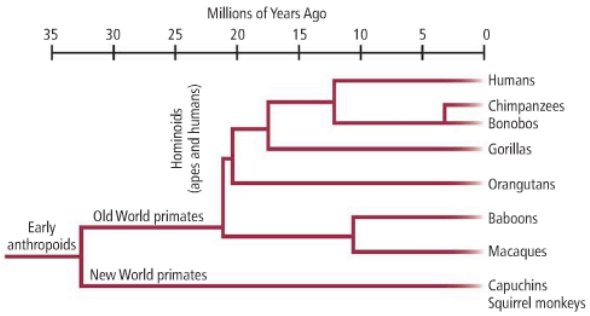


Figure 16.11 Orangutans, gorillas, bonobos, and chimpanzees all diverged from an ancestral anthropoid.

Hominoid characteristics Hominoids are the largest of the primates, and they have the largest brain size in relation to their body size. They tend to have broad pelvises, long fingers, no tail, and flexible arm and shoulder joints. They also have semi-upright or upright posture, and, except for hominins, their arms are longer than their legs. Their teeth are less specialized than those of other animals, and their molars have a distinctive pattern that scientists use to distinguish hominoid fossils from other primate fossils.

Hominoid biogeography During the Miocene (24–5 mya), the world's climate became warmer and drier. As a result, tropical rain forests in Africa began to shrink. Many new animals, including new hominoids, evolved as they adapted to the changing environments. Between about 23 and 14 mya, perhaps as many as 100 hominoid species existed. Early hominoids were more diverse than the modern apes, and they migrated from Africa to Europe and Asia.

Proconsul The best-known hominoid fossils, and some of the oldest, are those from the genus *Proconsul*. **Figure 16.12** shows a fossil skull of one *Proconsul* species discovered by Mary Leakey in Kenya in 1948. This *Proconsul* species generally had the smallest brains of the hominoids. Most had freely moving arms and legs, and while they lived predominantly in trees, some might have had the ability to walk upright. Some scientists think that this *Proconsul* species is a human ancestor, but others suggest that one of the European hominoids—whose fossils are in some ways more humanlike than *Proconsul*—might have returned to Africa at the end of the Miocene and given rise to the human line.

Hominins

The lineage that most likely led to humans split off from the other African apes sometime between 8 and 5 mya. The hominins include humans and all their extinct relatives. These extinct relatives are more closely related to humans than to chimpanzees. The time line in **Figure 16.13** highlights some important hominin discoveries.

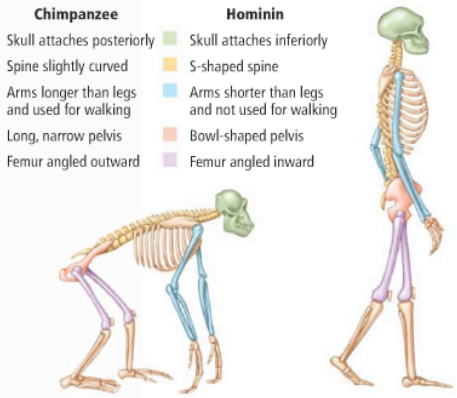
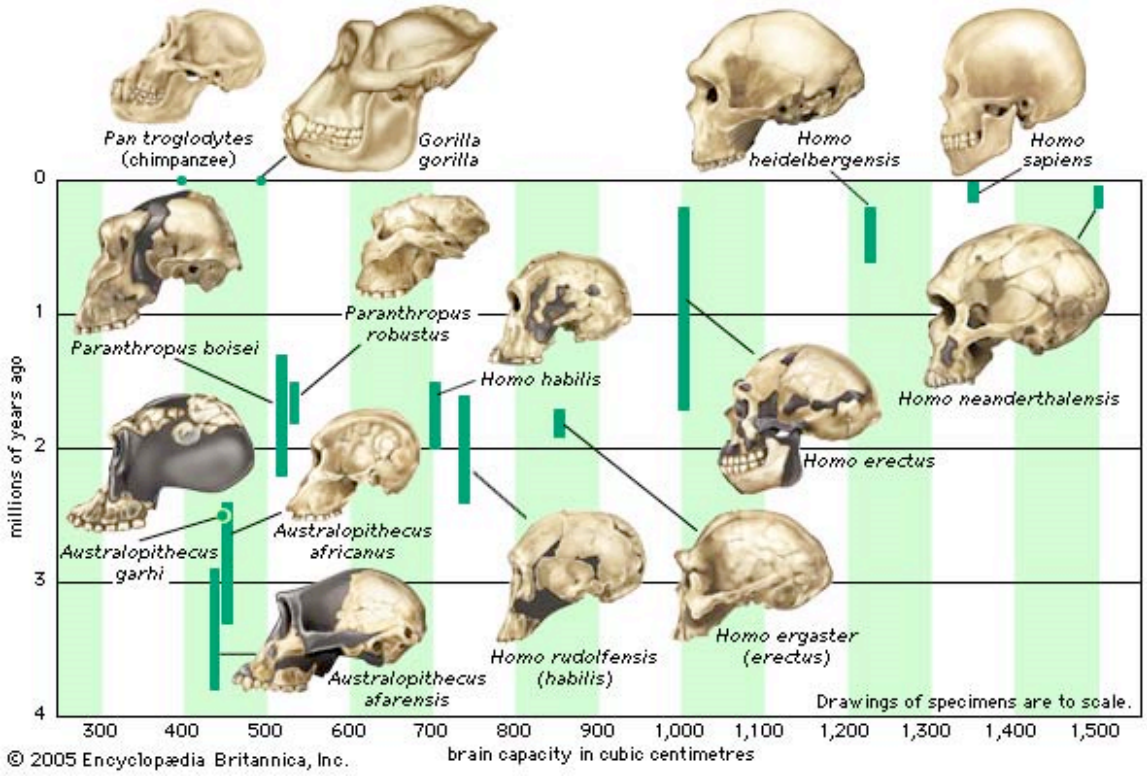


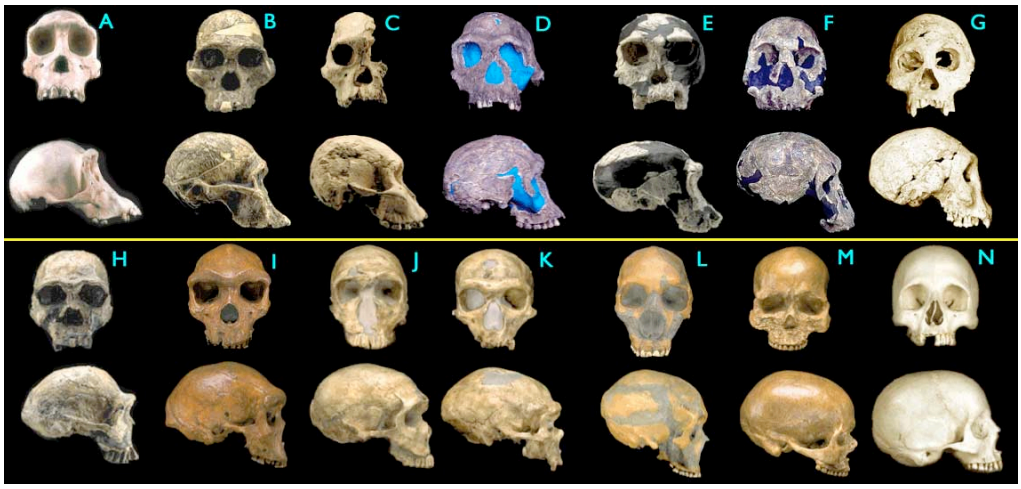
Figure 16.14 A comparison between chimpanzee and hominin skeletons illustrates evolutionary changes leading to bipedalism.
Observe and Infer *What differences in the lengths of the arms and the legs do you detect?*

Hominin characteristics Hominins have bigger brains than other hominoids, with more complexity in parts of the brain where high-level thought occurs. The hominin face is thinner and flatter than that of other hominoids. Hominin teeth are also smaller. With lengthened thumbs and more flexible wrists, hominins have high manual dexterity. Hominins are also **bipedal,** which means that they can walk upright on two legs.

Examine **Figure 16.14,** which illustrates anatomical differences in a quadruped and a biped. When becoming bipedal, hominins developed a fully upright stance, shortened arms, restructured pelvic bones and foot bones, and a change in the position of the head on the spinal cord. In quadrupedal animals, or those that walk on all four limbs, the foramen magnum—the hole in the skull where the spine extends from the brain—is located at the back of the skull. In hominins, it is positioned at the base of the skull.

- **<u>Compare the skulls and brain capacities of the different primates</u>** - can look at textbook pages here w/pics for answers





- Lesser apes and greater apes

Apes Only a handful of ape species exist today. Apes generally have larger brains in proportion to their body size than monkeys. They also have longer arms than legs, barrel-shaped chests, no tails, and flexible wrists. They are often highly social and have complex vocalizations. They are classified into two subcategories: the lesser apes, which include the gibbons and siamangs, and the great apes, which include orangutans, gorillas, chimpanzees, and humans.

Lesser apes The Asian gibbons and their close relatives, the larger siamangs, are the arboreal gymnasts of the ape family. Though they have the ability to walk on either two or four legs like all great apes, they generally move from branch to branch using a hand-over-hand swinging motion called brachiation. This motion, as shown in **Figure 16.6,** enables an adult gibbon to move almost 3 m in one swing.

Great apes Orangutans are the largest arboreal primates and the only great ape species that lives exclusively in Asia. Orangutans are large enough that the males are often more comfortable on the ground, though they are not efficient walkers. Female orangutans give birth once every eight years and nurse their young for up to six years. A male orangutan with prominent cheek pads and female orangutan with her offspring are shown in **Figure 16.7.**

The gorillas are the largest of the primates. Like all great apes, they are predominantly terrestrial animals. They walk on all four limbs, supporting themselves by their front knuckles. Also, like other great apes, they use sticks as simple tools in the wild, and some living in captivity have been taught to recognize characters and numbers.

- Hominids: what are they? -

Chimpanzees and their close relatives, the bonobos, are also knuckle-walkers. They have well-developed communication systems, such as body positions and gestures, and social behavior, and they live in a wide variety of habitats. They are more like humans in their physical structure and behavior than any other primate. The bonobo, shown in **Figure 16.8,** is slightly smaller than the chimpanzee. It was once called the "pygmy chimpanzee," but it now is considered a separate species.

Humans are included in the great ape family. They are then classified in a separate subcategory of hominids called hominins. **Hominins** are humanlike primates that appear to be more closely related to present-day humans than they are to present-day chimpanzees and bonobos. Though many species of hominins have existed on Earth, only one species—the group to which you belong—survives today. The diagram in **Figure 16.9** illustrates evolutionary relationships among primates.

Primate Evolution

Most primates today are arboreal. Prehensile tails, long limbs, binocular vision, brachiation, and opposable digits are traits that help them take full advantage of their forest environments.

Arboreal adaptation Some scientists suggest that primates evolved from ground-dwelling animals that searched for food in the top branches of forest shrubbery. They then evolved into additional food-gathering niches in trees. For example, the flexible hand with its opposable digits evolved not to grasp tree branches but to catch insects. Other scientists suggest that the rise of flowering plants provided new niche opportunities, and that arboreal adaptations allowed primates to take advantage of the fruits and flowers of trees.

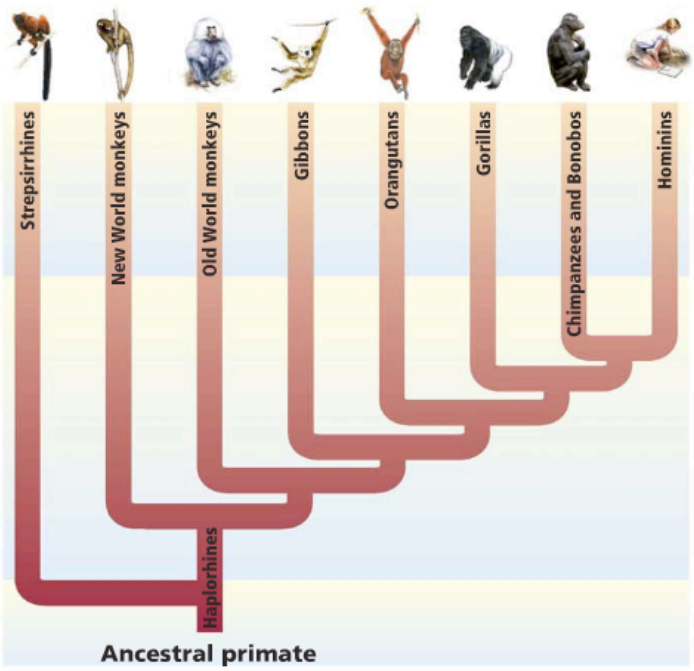


Figure 16.9 This branching diagram illustrates the diverging pattern of primate evolution.
Trace *Which primate was the earliest to diverge?*

- Bipedal - The ability to walk upright on two legs, which primates can do, specifically Hominins.

Hominin fossils Bipedalism evolved before many other hominin traits, and it is often used to identify hominin fossils. The earliest fossils of species that show some degree of bipedalism are 6–7 million years old. The first hominins that were truly bipedal, however, were the australopithecines (aw stray loh PIH thuh seens).

Australopithecines lived in the east-central and southern part of Africa between 4.2 and 1 mya. They were small—the males were only about 1.5 m tall—and they had apelike brains and jaws. However, their teeth and limb joints were humanlike.

Taung baby The anthropologist Raymond Dart (1893-1988) identified the first australopithecine fossil, the "Taung baby," in Africa in 1926. He called the species *Australopithecus africanus,* meaning "southern ape from Africa." *A. africanus* likely lived between 3.3 and 2.3 mya. The placement of the foramen magnum in the skull of the Taung baby, shown in **Figure 16.15,** convinced Dart that *A. africanus* was bipedal. Not everyone agreed because *A. africanus* had a small brain. Some scientists thought that larger brains evolved before bipedalism. The question continued to be debated for many years, even after the discovery of other African australopithecine fossils such as *A. bosei* and *A. robustus* that indicated bipedalism and small brains.

Lucy In 1974 in Kenya, the anthropologist Donald Johanson discovered an australopithecine skeleton that helped resolve the debate. Lucy is one of the most complete australopithecine fossils ever found. She was a member of the species *A. afarensis,* which lived between 4 and 2.9 mya.

Lucy was about the size of a chimpanzee. She had the typical australopithecine skull and small brain, and her arms were still somewhat long in proportion to her legs. She also had finger bones that were more curved than those of modern humans, which indicates that she was capable of arboreal activity. But her hip and knee joints were humanlike, and it was clear that she walked upright. A few years later, Mary Leakey uncovered further evidence that australopithecines were bipedal when she discovered fossilized australopithecine footprints. Lucy's skeleton and the footprints of her relatives are illustrated in **Figure 16.16.**

Mosaic pattern Like other hominin fossils, Lucy and her relatives show a patchwork of human and apelike traits. In this way, they follow a mosaic pattern of evolution. Mosaic evolution occurs when different body parts or behaviors evolve at different rates. For example, hominins developed the ability to walk upright nearly two million years before they developed modern flat faces and larger brains.

- Raymond Dart's discovery – **See Hominin Fossils page for answers**
  - what the interesting about the skull he found?
  - What was it called?
- Australopithecine – **See Hominin Fossils page for answers**
  - what are they?
  - Characteristics
- "Lucy" – **See Hominin Fossils page for answers**
- Forum magnum, brow ridge, sagittal crest

In quadrupedal animals, or those that walk on all four limbs, the foramen magnum—the hole in the skull where the spine extends from the brain—is located at the back of the skull. In hominins, it is positioned at the base of the skull.

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  - Foramen Magnum – the hole in the skull where the spine extends from the brain
  - Brow ridge - refer to a bony ridge located above the eye sockets of all primates. In *Homo sapiens sapiens* (modern humans) the eyebrows are located on their lower margin.
  - Sagittal Crest - (in many mammals) a bony ridge on the top of the skull to which the jaw muscles are attached.
- *Homo habilis, Homo ergaster, Homo erectus:* characteristics of them, relative brain size to each other and modern humans – **Use Text below for answers**
  - Characteristics
  - Relative brain size to each other and modern humans
  - Tools, fire, caves - used these

The Genus *Homo*

The African environment became considerably cooler between 3 and 2.5 mya. Forests became smaller in size, and the range of grasslands was extended. The genus ***Homo,*** which includes living and extinct humans, first appeared during these years and although the fossil record is lacking fossils, many scientists infer that they evolved from an ancestor of the australopithecines.

Homo species had bigger brains, lighter skeletons, flatter faces, and smaller teeth than their australopithecine ancestors. They are also the first species known to control fire and to modify stones for tool use. As they evolved, they developed language and culture.

Homo habilis used stone tools The earliest known species that is generally accepted as a member of the genus *Homo* is *Homo habilis,* called "handy man" because of its association with primitive stone tools. This species lived in Africa between about 2.4 and 1.4 mya. **Figure 16.17** shows a scientific illustrator's idea of what *H. habilis* might have looked like.

H. habilis possessed a brain averaging 650 cm^3, about 20 percent larger than that of the australopithecines. It also had other *Homo* species traits, including a smaller brow, reduced jaw, flatter face, and more humanlike teeth. Like australopithecines, it was small, long-armed, and it seems to have retained the ability to climb trees. Other *Homo* species might have coexisted with *H. habilis*, among them a species called *Homo rudolfensis.* Because few fossils of *H. rudolfensis* have been found, its exact relationship to the rest of the *Homo* line is uncertain.

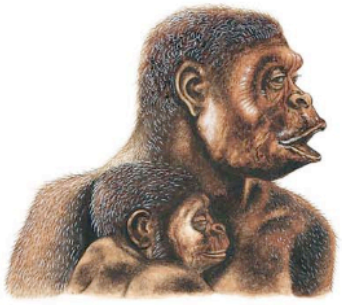
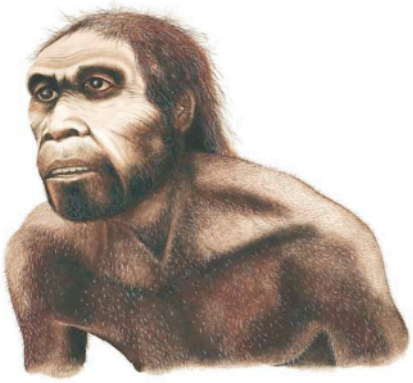


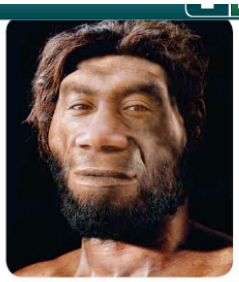
Figure 16.17 Scientific illustrators use fossils and their knowledge of anatomy to create drawings of what *H. habilis* might have looked like.



■ **Figure 16.18** Models of nonliving species also can be created from fossil remains. *H. ergaster* appeared in the fossil record about 1.8–1.3 mya.

***Homo ergaster* migrated** Within about 500,000 years of the appearance of *H. habilis*, another *Homo* species, *Homo ergaster*, emerged with an even larger brain. *H. ergaster*, illustrated in **Figure 16.18**, appeared only briefly in the fossil record, from about 1.8 to 1.3 mya. *H. ergaster* was taller and lighter than *H. habilis*, and had longer legs and shorter arms. Its brain averaged 1000 cm^3, and it had a rounded skull, reduced teeth, and what many scientists think is the first human nose (with the nostrils facing downward).

Tools Carefully made hand axes and other tools associated with *H. ergaster* fossils suggest to some scientists that *H. ergaster* was a hunter, but others think that *H. ergaster* was primarily a scavenger and used the tools to scrape the meat off of scavenged bones.



■ **Figure 16.19** *H. erectus* might have lived in caves, made tools, and used fire.
Explain *some of the advantages* **H. erectus** *would have over* **H. ergaster.**

Migration Both scavenging and hunting are associated with a migratory lifestyle, and *H. ergaster* appears to have been the first African *Homo* species to migrate in large numbers to Asia and possibly Europe, perhaps following the trail of migrating animals. The later Eurasian forms of *H. ergaster* are called *Homo erectus*. Because *H. ergaster* shares features with modern humans, scientists hypothesize that *H. ergaster* is an ancestor of modern humans.

***Homo erectus* used fire** *H. erectus*, illustrated in **Figure 16.19**, lived between 1.8 million and 400,000 years ago and appears to have evolved from *H. ergaster* as it migrated out of Africa. While some scientists consider *H. ergaster* and *H. erectus* a single species, *H. erectus* appears to have evolved traits that the early African *H. ergaster* species did not have. Members of this species seem to have been more versatile than their predecessors, and they adapted successfully to a variety of environments. *H. erectus* includes "Java Man," discovered in Indonesia in the 1890s, and "Peking Man," discovered in China in the 1920s.

In general, *H. erectus* was larger than *H. habilis* and had a bigger brain. It also had teeth that were more humanlike. Brain capacity ranged from about 900 cm^3 in early specimens to about 1100 cm^3 in later ones. It was as tall as *H. sapiens* but it had a longer skull, lower forehead, and thicker facial bones than either *H. ergaster* or *H. sapiens*. It also had a more prominent browridge. Evidence indicates that *H. erectus* made sophisticated tools, used fire, and sometimes lived in caves.

■ **Figure 16.20** Scientists are debating whether *H. floresiensis* is a new species. The *H. floresiensis* skull on the left is smaller than

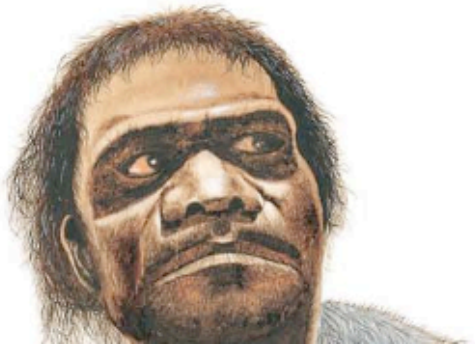
- Neanderthals – what they are, characteristics – **See below for answers**
  - What they are

- Characteristics

***Homo neanderthalensis* built shelter** A distinct human species called *Homo neanderthalensis,* or the **Neanderthals,** evolved exclusively in Europe and Asia about 200,000 years ago, likely from *H. erectus* or a *Homo* intermediary. Neanderthals were shorter but had more muscle mass than most modern humans. Their brains were sometimes even larger than the brains of modern humans, though the brains might have been organized in different ways. Neanderthals had thick skulls, bony browridges, and large noses. They also had a heavily muscled, robust stature, as illustrated in **Figure 16.21.** Evidence of heavy musculature appears in the extremely large muscle attachments and the bowing of the long bones.

Neanderthals lived near the end of the Pleistocene ice age, a time of bitter cold. Their skeletons reflect lives of hardship; bone fractures and arthritis seem to have been common. There is evidence that they used fire and constructed complex shelters. They hunted and skinned animals, and it is possible that they had basic language. There is also some evidence that they cared for their sick and buried their dead.

Are Neanderthals our ancestors? In some areas of their range, particularly in the Middle East and southern Europe, Neanderthals and modern humans overlapped for as long as 10,000 years. Some scientists suggest that the two species interbred. However, DNA tests on fossil bones suggest that Neanderthals were a distinct species that did not contribute to the modern human gene pool. Neanderthals went extinct about 30,000 years ago.



Emergence of Modern Humans

The species that displaced the Neanderthals, *Homo sapiens*, is characterized by a more slender appearance than all other *Homo* species. They have thinner skeletons, rounder skulls, and smaller faces with prominent chins. Their brain capacity averages 1350 cm^3. *H. sapiens* first appeared in the fossil record, in what is now Ethiopia, about 195,000 years ago. These early *H. sapiens* made chipped hand axes and other sophisticated stone tools. They appear to have had the ability to use a range of resources and environments, and at some point they began migrating out of Africa. **Table 16.2** compares modern humans with other *Homo* species.

Table 16.2 **Characteristics of the *Homo* species**

Concepts in Motion
Interactive Table To explore more about the *Homo* species, visit biologygmh.com.

Species	Skull	Time in fossil record	Characteristics
Homo habilis		2.4–1.4 million years ago	• Average brain had a capacity of 650 cm^3 • Used tools
Homo ergaster		1.8–1.2 million years ago	• Average brain had a capacity of 1000 cm^3 • Had thinner skull bones • Had humanlike nose
Homo erectus		1.8 million–400,000 years ago	• Average brain had a capacity of 1000 cm^3 • Had thinner skull bones • Used fire
Homo neanderthalensis		300,000–200,000 years ago	• Average brain had a capacity of 1500 cm^3 • Buried their dead • Possibly had a language
Homo sapiens		195,000 years ago to present	• Average brain has a capacity of 1350 cm^3 • Does not have browridge • Has a small chin • Has language and culture

- Cro-Magnons – what they are, characteristics – **See text below**
  - What they are

- Characterisitcs

The beginning of culture The first evidence of complex human culture appeared in Europe only about 40,000 years ago, shortly before the Neanderthals disappeared. Unlike the Neanderthals, early modern humans expressed themselves symbolically and artistically in decorative artifacts and cave drawings, as illustrated in **Figure 16.23.** They developed sophisticated tools and weapons, including spears and bows and arrows. They were the first to fish, the first to tailor clothing, and the first to domesticate animals. These and many other cultural expressions marked the appearance of fully modern humans, the subspecies *Homo sapiens*. Some people call them **Cro-Magnons.** They represent the beginning of historic hunter-gatherer societies.

Connection to History Humans continued their migration throughout Europe and Asia. They probably reached Australia by boat and traveled to North America via a land bridge from Asia. From North America, they spread to South America. They adapted to new challenges along the way, leaving behind a trail of artifacts that we study today.

Figure 16.23 Cro-Magnons were known for their sophisticated cave paintings, tools, and weapons. This painting was found in Lascaux Cave in France.

- Out of Africa hypothesis - The hypothesis that all humans originated in Africa.
- Mitochondrial Eve - The idea that all modern human beings can trace their ancestry back to a single woman who lived 200,000 years ago in Africa. This one woman was nicknamed “Eve” (a.k.a., “mitochondrial

Eve").

Out-of-Africa hypothesis The world's population 200,000 years ago looked significantly different than it does today. It was inhabited by a morphologically diverse genus of hominins, including primitive humans, Neanderthals, and modern humans, as illustrated in **Figure 16.22.** By 30,000 years ago, however, only modern humans remained. Some scientists propose that these modern humans evolved from several dispersed populations of early *Homo* species at the same time in different areas of the world. According to this multiregional evolution model, modern races of humans arose in isolated populations by convergent evolution.

Most scientists explain the global dominance of modern humans with the African Replacement model or, more commonly, the Out-of-Africa hypothesis. According to this hypothesis, which was first proposed by Christopher Stringer and Peter Andrews of the British Museum of Natural History in 1988, modern humans evolved only once, in Africa, and then migrated to all parts of the world, eventually displacing other hominins.

"Mitochondrial Eve" The Out-of-Africa hypothesis was supported by mitochondrial DNA analysis of contemporary humans in the early 1990s. Mitochondrial DNA changes very little over time, and humans living today have nearly identical mitochondrial DNA. Researchers Allan Wilson and Rebecca Cann of the University of California, Berkeley, reasoned that the population with the most variation should be the population that has had the longest time to accumulate diversity. This was exactly what they found in the mitochondrial DNA of Africans. Because mitochondrial DNA is inherited only from the mother, this analysis suggested that *H. sapiens* emerged in Africa about 200,000 years ago from a hypothetical "Mitochondrial Eve."

Later, work by other scientists studying DNA sequences in the male Y chromosome yielded similar results. While some scientists think that a single movement of only a few hundred modern humans ultimately gave rise to the world's current population, others think the process occurred in phases, with some interbreeding among the species that humans displaced.